

**INVESTIGATION OF  
IGNITER COMPOSITION FIRE  
BAY 9 BUILDING G-11  
LONESTAR ARMY AMMUNITION PLANT  
15 MAY 1991**

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MUNITIONS AND CHEMICAL COMMAND**



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## EXECUTIVE SUMMARY

1. An explosion occurred in bay 9, building G-11, Lone Star Army Ammunition Plant (AAP), Texarkana, TX, at approximately 1417, 15 May 1991. There were no injuries or deaths. Building G-11 was being used to remotely mix 45 pounds of igniter mix. The igniter mix is used in the tracer element of the 120mm family of tank gun ammunition. All items are produced under third-party contract by Day & Zimmermann, Inc.

2. Operations prior to the explosion proceeded normally. The operator had completed one batch of igniter mix earlier in the day. He was mixing the second batch of the day and remotely dumping it onto the dial table when the incident occurred.

3. The physical evidence and examination of the videotape indicate ignition took place outside the mixing bowl on the dial table. The reaction was centered on the draw-off dial between the 11 o'clock and 2 o'clock position. This is indicated by the bending of the dial table, other physical evidence, and the high-speed videotape. This caused a hot spot between the 12 o'clock and 1 o'clock position resulting in the ignition of mix on the dial. This resulted in propagation to the remaining mix on the dial, in the collection containers, and in the mixer. The ignition may be attributable to either electrostatic discharge or friction and heat.

a. Static electricity: The most probable cause of initiation is electrostatic charge discharging between the wiper arm, collection can, and draw-off table. The addition of acetone in sufficient quantity to dissolve the chlorinated rubber and the mixing action of the duller will effectively render this normally conductive mix into a nonconductive mix. A nonconductive mix will build up a static charge due to the triboelectrification at a rate depend upon the velocity of movement of the particles. Possible discharge path would be the dial wiper in close proximity to the mixture as it fills the collection container. It would provide a discharge path that could cause ignition.

b. Friction/Heat: A secondary cause of initiation is friction and heat due to varied clearances, and foreign matter buildup on the lower surfaces of the wiper blades. Behavioral characteristics of similar mixtures containing magnesium and barium peroxide indicate these mixtures are sensitive to friction. The clearance of the dial wipers, the uneven surface on the lower edges, and rotational speed of the wipers could cause friction and heat buildup sufficient for initiation. Contamination found on the lower surfaces of the wiper arms could also change the clearance of the dial wiper arms to the draw-off table causing the potential for increased friction and heat buildup.

## 1. Introduction:

a. An explosion occurred in bay 9, building G-11, Lone Star AAP, Texarkana, TX, at approximately 1417, 15 May 1991. There were no injuries or deaths reported. Building G-11 was being used to remotely mix 45 pounds of igniter mix. The igniter mix is used in the tracer element of the 120mm family of tank gun ammunition. All items were produced under third-party contract by Day & Zimmermann, Inc.

b. Operations prior to the explosion proceeded with no anomalies. The operator had completed one batch of igniter mix earlier in the day. He was mixing the second batch of the day and remotely dumping it onto the dial table when the incident occurred.

c. There were no deaths or injuries, but there was major property damage to the building and equipment.

d. A video system was in use during the mixing process. Two cameras were used by the operator to monitor the operation. One camera was focused on the dial table and was mounted on the east wall of the bay. The second camera was mounted 4 feet above the mixing bowl allowing the operator to monitor the motion of the mulling wheel and the plows. The camera was attached to a high-speed video recording system and provided a videotape of the entire mixing process in the bowl.

e. The igniter mix batch was being remotely dumped when the incident occurred. The mixer door had been open approximately 30 seconds. The mulling wheel stopped rotating approximately 5 1/2 seconds before the incident.

f. The operator was preparing to stop the operation of the plow and muller wheel when the deflagration took place. The reaction was centered on the draw-off dial table between the 11 o'clock and 2 o'clock position as indicated by the bending of the dial table.

## 2. General History of the Igniter Composition at Lone Star AAP:

a. The igniter mix is used in the tracer element of the 120mm family of tank gun ammunition. They include: M829, APFSDS-T; M830, HEAT-MP-T; M831, TP-T; and M865, TPCSDS-T.

b. The igniter composition was first produced in March 1989. Since that time, 32 batches have been produced in building G-11. There has been one previous incident of process deflagration in bay 9, building G-11. The incident occurred on 5 September 1990. There were no injuries, but significant damage to the facilities and equipment was incurred. The incident initiated inside the mixing bowl. The mixer was in operation at the time, and the mixer door was closed. The building sustained \$17,277 in damages. The exact cause of the incident was not determined.

c. The igniter composition has also been involved in at least 31 downstream process incidents occurring between 2 May 1989 and 22 May 1991. Typical examples are provided below:

(1) A process deflagration occurred during pelleting operations. It was caused by friction or spark.

(2) Two Tracer and Plug Assemblies ignited during final assembly. It was caused by friction or static discharge.

(3) Three partially assembled Tracer and Plug Assemblies and quantity of pellets ignited during final assembly. It was caused by friction.

(4) Two Tracer and Plug Assemblies ignited during consolidation of the igniter charge. It was caused by friction.

(5) A fin ruptured occurred during the consolidation of igniter composition into the Fin Assembly.

(6) A flash occurred on a conveyor belt during the transfer of a Trace and Plug Assembly.

(7) During the pressing of igniter pellets on a press, a detonation occurred.

### 3. Building and Equipment:

a. Building G-11 is a single-story structure 44 feet wide by 127 feet long, containing 5,588 square feet of floor area. It was constructed in 1941 as a tracer, igniter, and incendiary composition preparation building. It contains 19 cubicles separated by 12-inch thick reinforced concrete dividing walls. It has a concrete floor with hollow clay tile walls on the west, north, and east sides.

b. There is a blowout wall and roof on the south end of the building, where the mixing cubicles are located. The roof on the remainder of the building is composed of asphalt composition shingles over wood decking.

c. Cubicle 9 and adjacent corridors were insulated with foil-backed rigid insulation when temperature/humidity control equipment was installed in October 1984. The mixing cubicles, adjacent corridors, and drying cubicles are equipped with ultraviolet fire detection and ultra-high-speed deluge systems.

d. The major equipment in bay 9 consists of the following:

- + Simpson Muller Mixer
- + Remote Draw-off System for Simpson Mixer
- + Eductor System
- + Remote Charging Device for Binder Material
- + Deluge System
- + Magnesium Dumper
- + Closed Circuit Television System

### 4. Damage:

a. Damage to the structure consisted of the blowing off the frangible wall and roof panels of bay 9, the adjacent bays, and corridor, plus cracking the side wall on the east side of the building. There was also damage to adjacent bay roofs, frangible walls, and frangible doors. Damage to the equipment in bay 9 was heavy. The material destroyed consisted of approximately 45 pounds of igniter mix and 6 pounds of acetone.

b. The majority of the fragments consisted of fiberglass panels and rigid insulation. There were also approximately 12 pieces of metal. Most were sections of metal flashing from the roof and were located within 20 feet of the building.

c. The particle board covering the window on the west wall of the building prevented a more complete venting at that spot and channeled the pressure wave against the corridor doors.

d. The total damages were \$44,972.

e. There were no deaths or injuries.

#### 5. Weather Conditions:

a. Weather conditions at the time of the accident were:

- + Sky: 2,100 feet broken clouds
- + Temperature: 74 Degrees F
- + Relative Humidity: 70%; raining
- + Winds: South at 12 mph
- + Barometric Pressure: 29.90 inches

b. Weather conditions did not contribute to the accident.

#### 6. Manufacture of Igniter Mix:

a. The igniter mix for the 120mm family of tank gun rounds has the following composition:

Chemical	Percent	Weight
Barium Peroxide	79 +/- 2.0	12.0 pounds
Magnesium	13 +/- 1.0	884.5 grams
Chlorinated Rubber	5 +/- 0.5	340.0 grams
Charcoal Dust	2 +/- 0.3	136.0 grams
Graphite	1 +/- 0.2	68.0 grams
Acetone:		6 pounds



b. This igniter mix is prepared at Lone Star AAP using a Simpson Mix Muller. The mixture involved is created by combining three 15-pound dry mixed batches of igniter composition with a prescribed amount of acetone and mixing in the Simpson Muller Mixer until it reaches the desired consistency.

c. The mixing process proceeds as follows:

(1) A preblended mixture of the barium peroxide, magnesium, chlorinated rubber, charcoal dust, and graphite is prepared before the wet mix process takes place. These chemicals are passed through a #4 mesh screen prior to being dry blended in building G-13. Three 15-pound premix batches are then transferred to building G-11, bay 9, for the wet mix process.

(2) The three 15-pound batches are remotely dumped into a Simpson Muller Mixer. Acetone is then placed in a binder dump station, and subsequently remotely dumped into the mixer bowl.

(3) The operator then remotely starts the mixer and allows it to run until the composition reaches the desired consistency. The operator judges by viewing through the video camera at which point the mixing process is complete. The operator then remotely starts the draw-off dial and opens the mixer door. The plow then pushes the mix out the door onto the dial. The rotating wiper blades of the draw-off system push the mix into the holes in the dial plate and into stainless steel containers below. Once the mixer bowl is empty, the mixer and rotating blades are turned off, and the mixer door closed.

(4) The stainless steel containers are then lowered away from the dial and are conveyed from the bay one at a time. Each container must be removed to storage before another is allowed to be released from the dial. Once all the containers are removed, the mixing process can begin anew, or cleaning of the mixer may occur.

7. Hazardous Component Safety Data Statements (HCSDSs):

a. Information on the igniter composition as it relates to sensitivity data (friction, impact, and electrostatic discharge) and hazard data (autoignition temperature, 5-second explosive temperature, and dust) were listed as 'UNKNOWN' on the HCSDS.

b. This is critical information needed by producer of the igniter mix.

#### 8. Military Specifications:

a. All chemicals used in the ignition mix are required to meet military specifications.

b. All chemicals met the applicable military specifications.

#### 9. Acetone:

a. The mixing of acetone and chlorinated rubber causes the development of an insoluble gelatinous substance. The material that forms will not be removed from the composition by the action of the mixer.

b. The amount of acetone added has been adjusted based on the incident history of the composition. It was increased to the present quantity as a result of the September 1990 incident. This results in a longer mixing time.

c. The use of methyl ethyl ketone (MEK) or acetone is permitted in this mix. Chlorinated rubber is more readily soluble in MEK than in acetone.

#### 10. Mixer:

a. The mixer involved in the incident has been in service at Lone Star AAP since July 1951. It shows signs of wearing out as a result of extended service and an undetermined number of previous incidents.

b. Worn areas were discovered in the hub area of the axle assembly in the mixing bowl. A sharpened edge and an indentation in the ring were discernible. Furthermore, extensive pitting of

the ring in the hub assembly was evident. The millwrights indicated they had not seen this pitting when they repaired the bowl after the September incident. The millwrights attributed this pitting to water buildup in that area. These hub anomalies could possibly cause a wobbling of the wheel and plow assembly.

11. Bowl:

a. The interior of the mixing bowl showed the presence of concentric circular grooves on the bottom of the bowl. The depth of the grooves was measured at four random locations. The depth varied from 0.007 inches to 0.015 inches. The maintenance personnel indicated that the grooves were there following the September 1990 incident. The grooves were hand-polished with emery cloth to attempt to smooth them down. It is not known if the depth of the grooves increased between September 1990 and May 1991.

b. There were marks on the side of the mixing bowl. The marks appeared from approximately the 7 o'clock to the 9 o'clock position. Eleven distinct sets of marks were visible and all had the appearance of being caused by metal to metal contact. The marks were vertically linear in arrangement. They occurred from approximately 4-8 inches above the floor of the bowl.

12. Mixing Bowl Plows:

a. Both of the plow blades were bent near the tip of the plow. It could not be determined if it was caused by the incident. However, it did not cause the incident.

b. There were differences in the thicknesses of the edges of both plow blades. This can be attributed to either normal wear or remanufacturing of the plows.

13. Muller Wheel:

a. The muller wheel was pitted and had a dent near the point where it meets the axle that links it to the plow assembly. These did not cause the accident.

b. The muller wheel stopped rotating approximately 5.5 seconds before the incident. It was determined that this was a natural stoppage due to the lowered level of mix in the bowl after the dumping action of the plows. It had no bearing on the cause of the incident.

c. A brown mark was observed that ran around the circumference of the axle at about the mid point of the axle where it connects the Muller Wheel to the plow arm assembly,. Additionally, light scoring was evident in other locations on the axle. The axle was polished after the September 1990 incident. This was judged not to have caused the incident.

#### 14. Dial Table:

a. The remote draw-off table and associated hardware were the prototype design for all other draw-off assemblies at Lone Star AAP. This equipment was installed in October 1984.

b. There was a buildup of material found between the wiper and the dial table. This material was nonconductive. The age of the material was not known. A pitted area discovered on the dial table near the 1 o'clock position. There was a corresponding mark as well as uneven wear on the dial wiper. There was also a good signature of a reaction at this location. This would indicate a probable point of initiation.

#### 15. Dial Wipers:

a. The four dial wipers all had uneven surfaces on the lower edges. There was misalignment of the wiper system. Viton was found on the wiper blades. The wipers were not adequately cleaned at some time prior to the incident.

b. The misalignment and uneven surfaces could cause friction between the surface of the dial table and the wiper arm.

#### 16. Ultra-High-Speed Deluge:

a. Routine checks of the deluge system indicated that there were no problems with the deluge. The system functioned as designed during the incident.

b. The deluge system had 17 nozzles and 8 ultraviolet detectors. Several months prior to the incident, the response time of the system was checked. It was in excess of 100 milliseconds (detection to water at the nozzles). To decrease response time of the system, the water supply was looped, and a pressure tank was added. This reduced the response time to less than 70 milliseconds.

c. A review of the high-speed videotape (4.4 milliseconds per frame) revealed the deflagration (rapid burning of the mix) occurred in 5 frames or less than 25 milliseconds. The reaction time of the mix exceeds the capability of the deluge system to halt the reaction. However, the deluge system did reduce the damage done to the equipment and the structure.

#### 17. Bonding, Grounding, and Lightning Protection:

a. The bonding and grounding was checked in November 1990. The lightning protection system was checked in August 1990. No deficiencies were noted.

b. The metal ring attached to the dial table as a splash guard was incorrectly bonded. The caulking compound used to seal the space between the two parts served as an insulator. Also, there was no evidence of bonding between the metal drop chute and the dial table.

#### 18. Possible Causes:

a. It is plausible that the source of the ignition can be attributed to some anomaly in the mixing bowl area. The door of the mixing bowl was open at the time of the incident and this provides a path for propagation from the mixing bowl to the lower dial table. Furthermore, it was evident by examination of all components of the bowl that the potential for metal-to-metal contact from either the plows or the mixing wheel is present. However, detailed examination of the areas containing marks or grooves in the bowl, plows, or muller wheel failed to indicate a strong signature of the point of ignition/initiation. It is for this reason that the likelihood of the mixing bowl as the source of the deflagration was ruled out.

b. The physical evidence and examination of the videotape indicate ignition took place outside the mixing bowl on the dial table. The reaction was centered on the draw-off dial between the 11 o'clock and 2 o'clock position. This is indicated by the bending of the dial table, other physical, and the high speed videotape. This caused a hot spot between the 12 o'clock and 1 o'clock position resulting in the ignition of mix on the dial. This resulted in propagation to the remaining mix on the dial, in the collection containers, and in the mixer. The ignition may be attributable to either friction or electrostatics on the dial.

c. Static electricity: The mixture, under normal circumstances, when mixed dry, would be a conductive mixture with minimal possibility for static buildup due to triboelectrification. However, the addition of acetone in sufficient quantity to dissolve the chlorinated rubber and the mixing action of the muller will effectively render this normally conductive mix into a nonconductive mix. A nonconductive mix will build up a static charge due to the triboelectrification at a rate depend upon the velocity of movement of the particles. The static charge will not effectively have the ability to bleed off because of the insulative properties of the mix. Upon dumping, free falling mixture will increase the static charge potential (become greater) until it has the ability to find a discharge path. Possible discharge path would be the dial wiper in close proximity to the mixture as it fills the collection container. It would provide a discharge path that could cause ignition. The amount of static buildup and discharge would vary day to day, mix to mix, and could possibly present minimal hazards until the physical and mechanical parameters come together in the right amounts to generate the discharge rate sufficient to cause a spark.

d. Friction/Heat: Specific values for friction and impact were unknown for this mixture. However, behavioral characteristics of similar mixtures containing magnesium and barium peroxide indicate these mixtures are sensitive to friction. The clearance of the dial wipers, the uneven surface on the lower edges, and rotational speed of the wipers could cause friction and heat buildup sufficient for initiation. Contamination found on the lower surfaces of the wiper arms could

also change the clearance of the dial wiper arms to the draw-off table. Again, this causes the potential for increased friction and heat buildup.

e. Other possible causes such as careless smoking, lightning, electrical short circuit, water, and electrical malfunctions were considered and discounted due to the absence of any evidence which would support such determinations.

19. Most Probable Cause:

a. The most probable cause of initiation is electrostatic charge discharging between the wiper arm, collection can, and draw-off table.

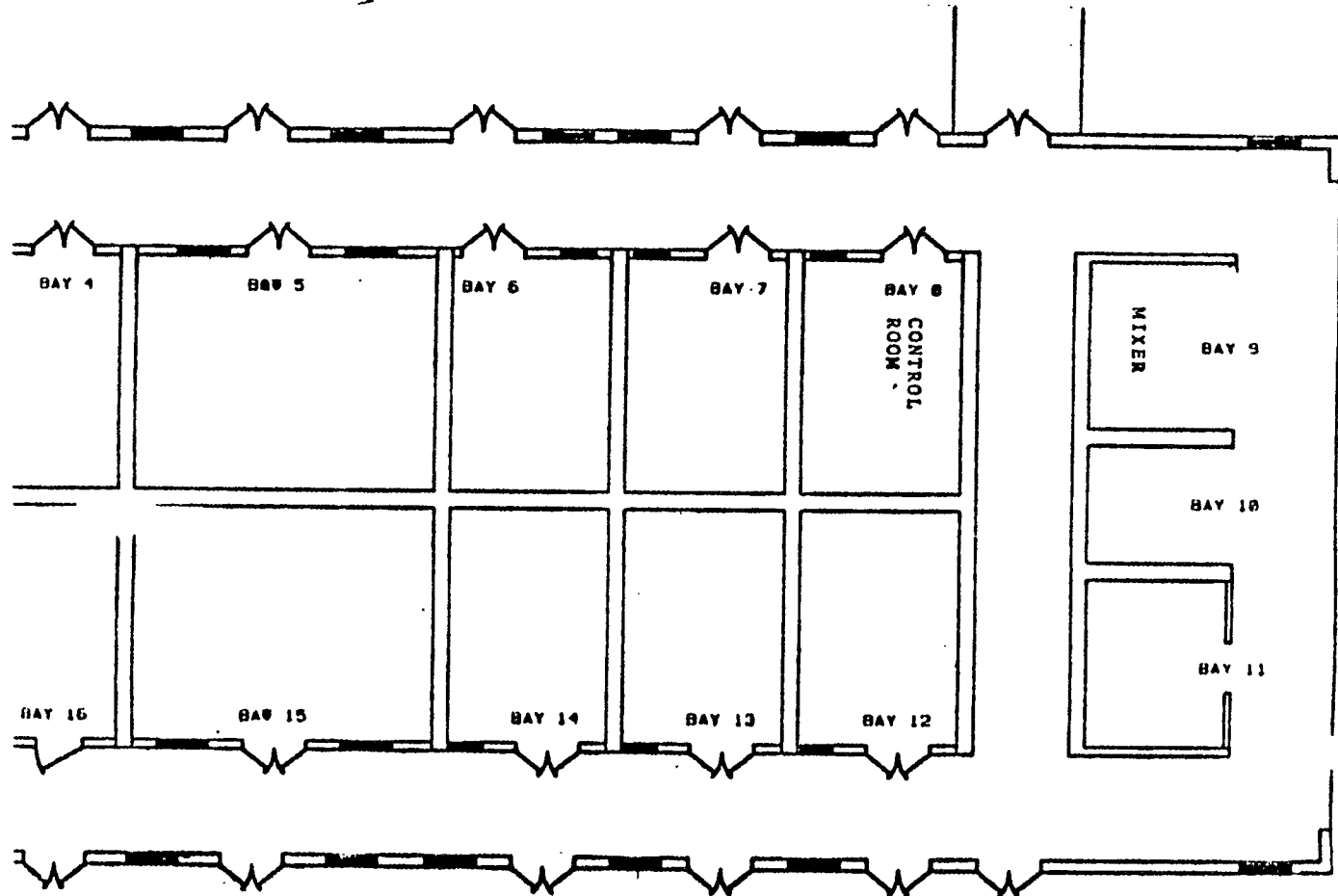
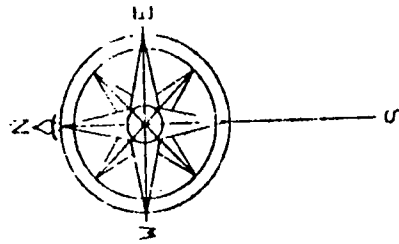
b. A secondary cause of initiation is friction and heat due to varied clearances, and foreign matter buildup on the lower surfaces of the wiper blades.

20. This report is based on the information contained in:

a. Report of Investigation, Building G-11, Bay 9, Lone Star Army Ammunition Plant, Texarkana, Texas, 15 May 1991. Members of the investigating team included: MAJ John Obal, Mr. Carl Morrison, Mr. Lyn Little, and Mr. Robert Loyd.

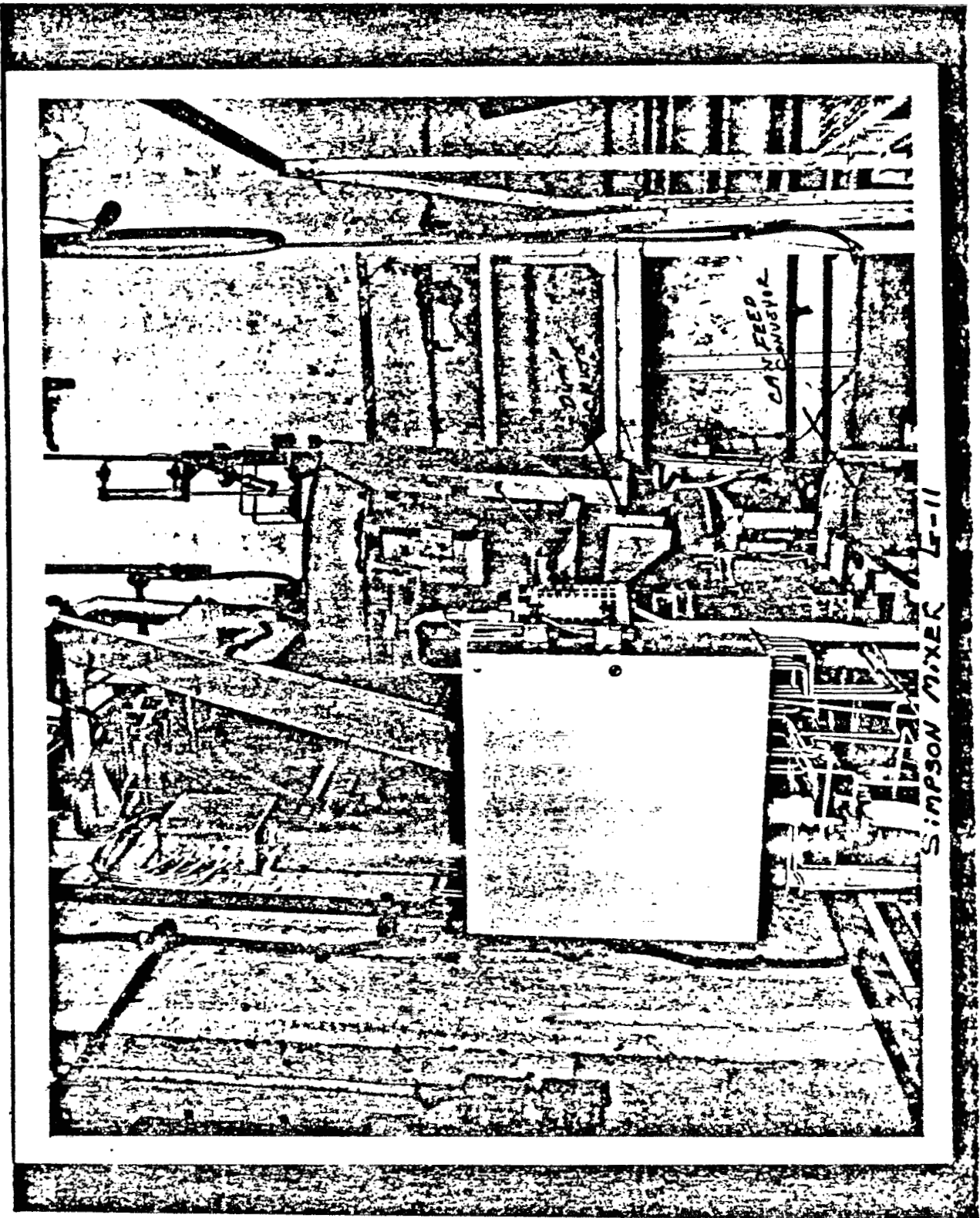
b. Outside Consultant's Report of Building G-11, Bay 9, Lone Star Army Ammunition Plant Incident dated 28 May 1991. Report was prepared by Mr. Fred McIntyre, Senior Engineer, Sverdrup Technology, Inc.

21. The author can be contacted at the U.S. Army Armament, Munitions, and Chemical Command, ATTN: AMSMC-SEP (Safety Office), Rock Island, IL 61299-6000. The telephone is commercial (309) 782-2975 or DSN 793-2975.

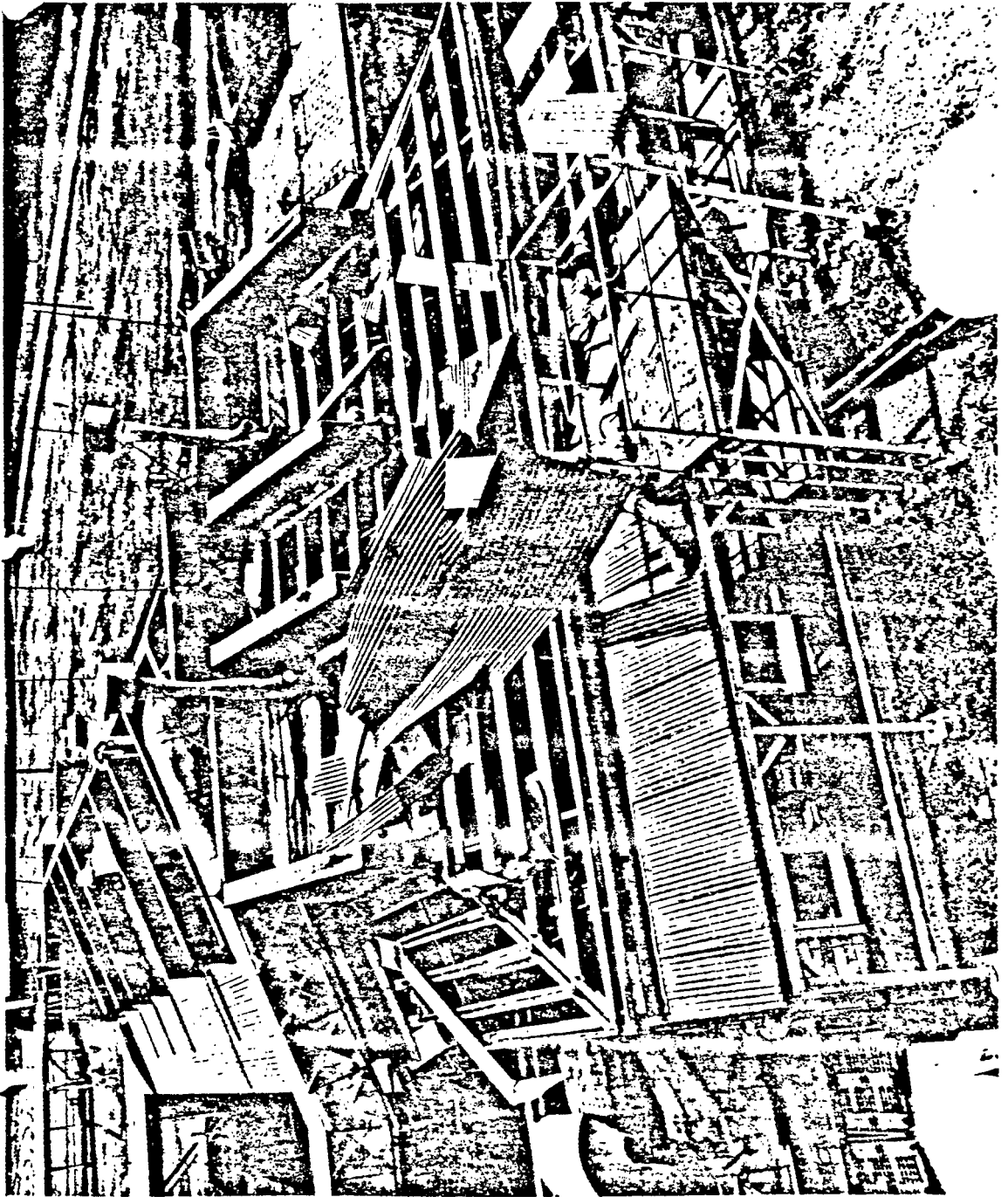


*PARTIAL FLOOR PLAN OF BLDG G-11*

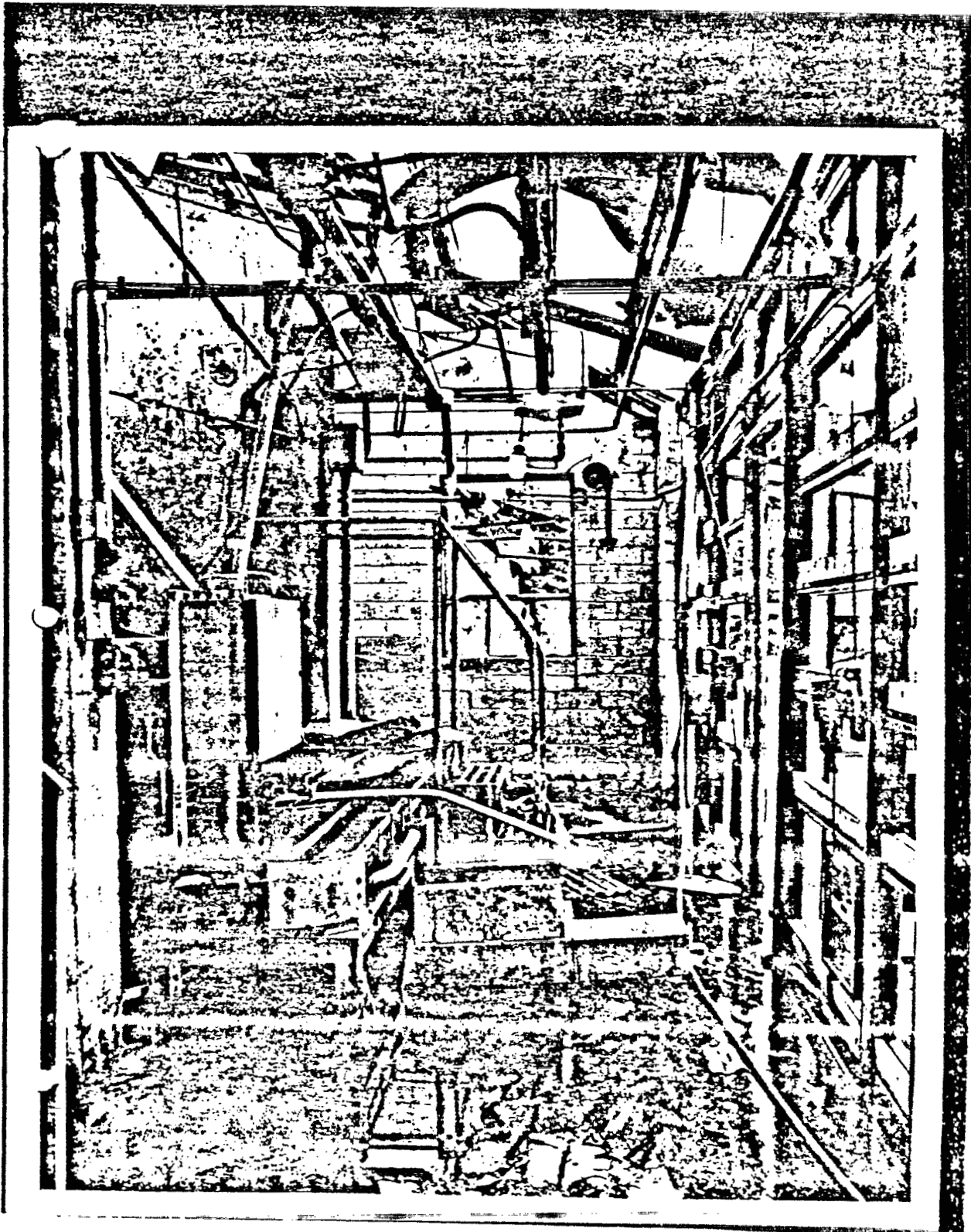




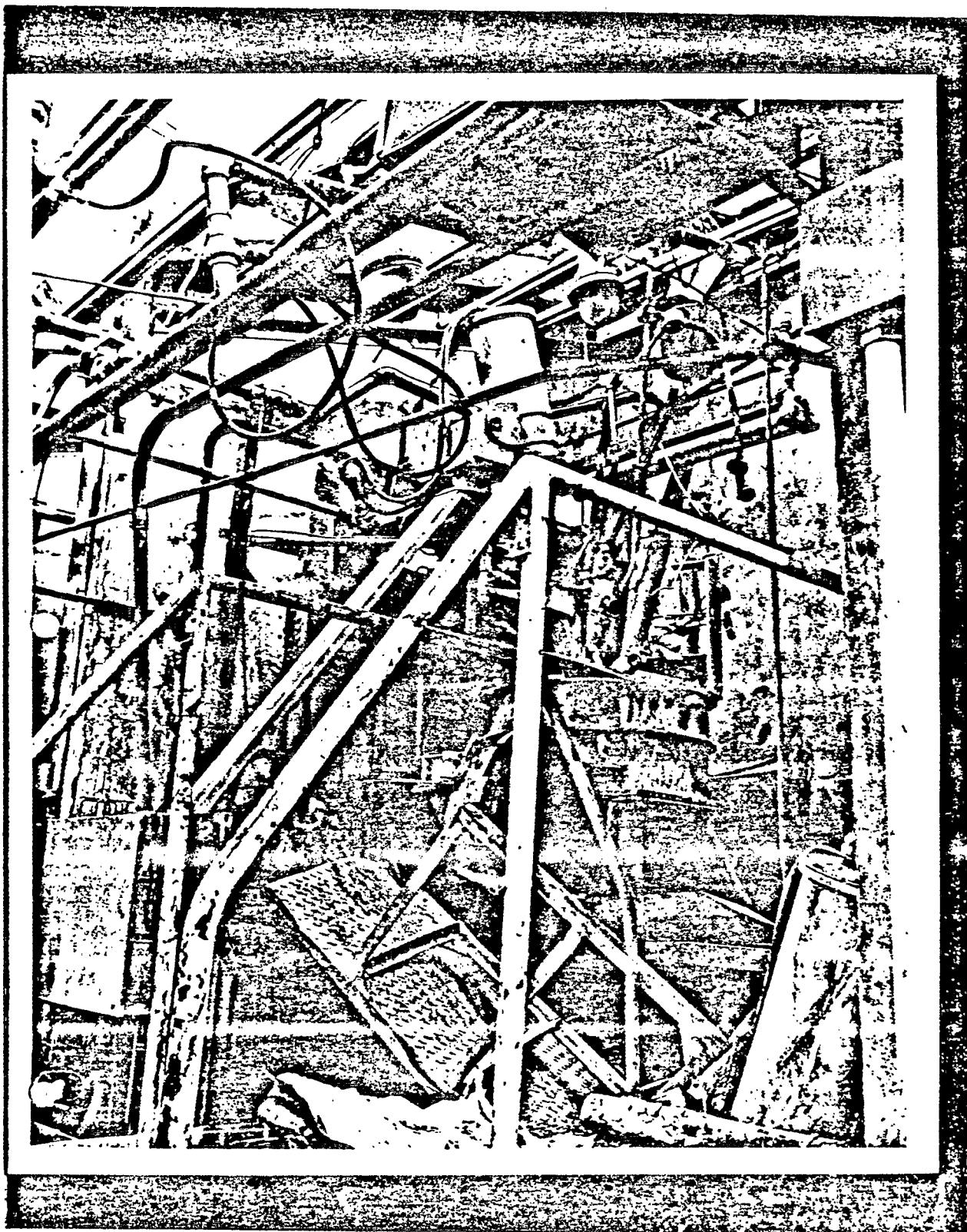
Bay 9 before explosion



Exterior of Bldg G-11 after explosion. Bay 9 is on the right side of the three bays shown in the front of the picture.

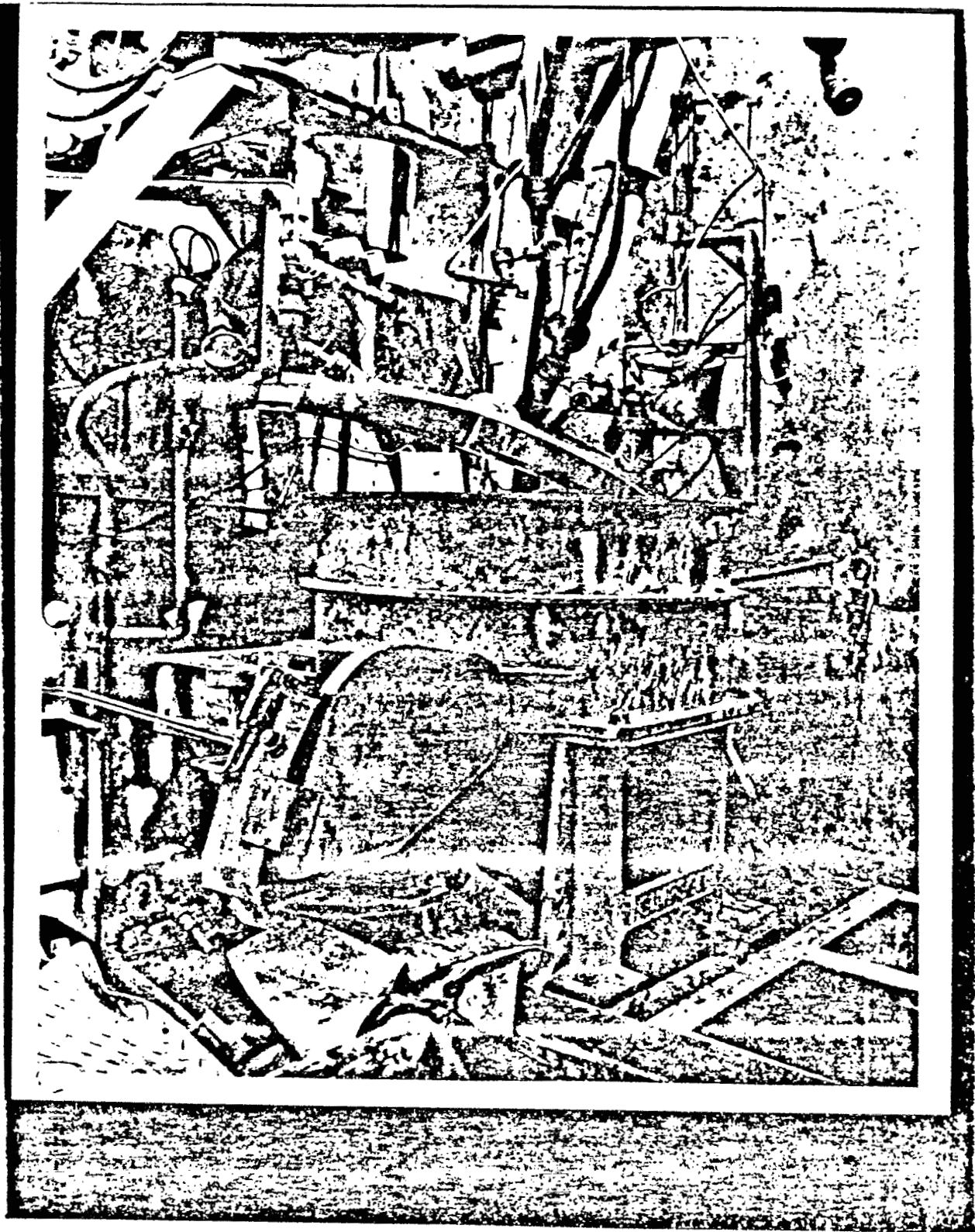


Corridor in front of Bay 9



Bay 9 after explosion

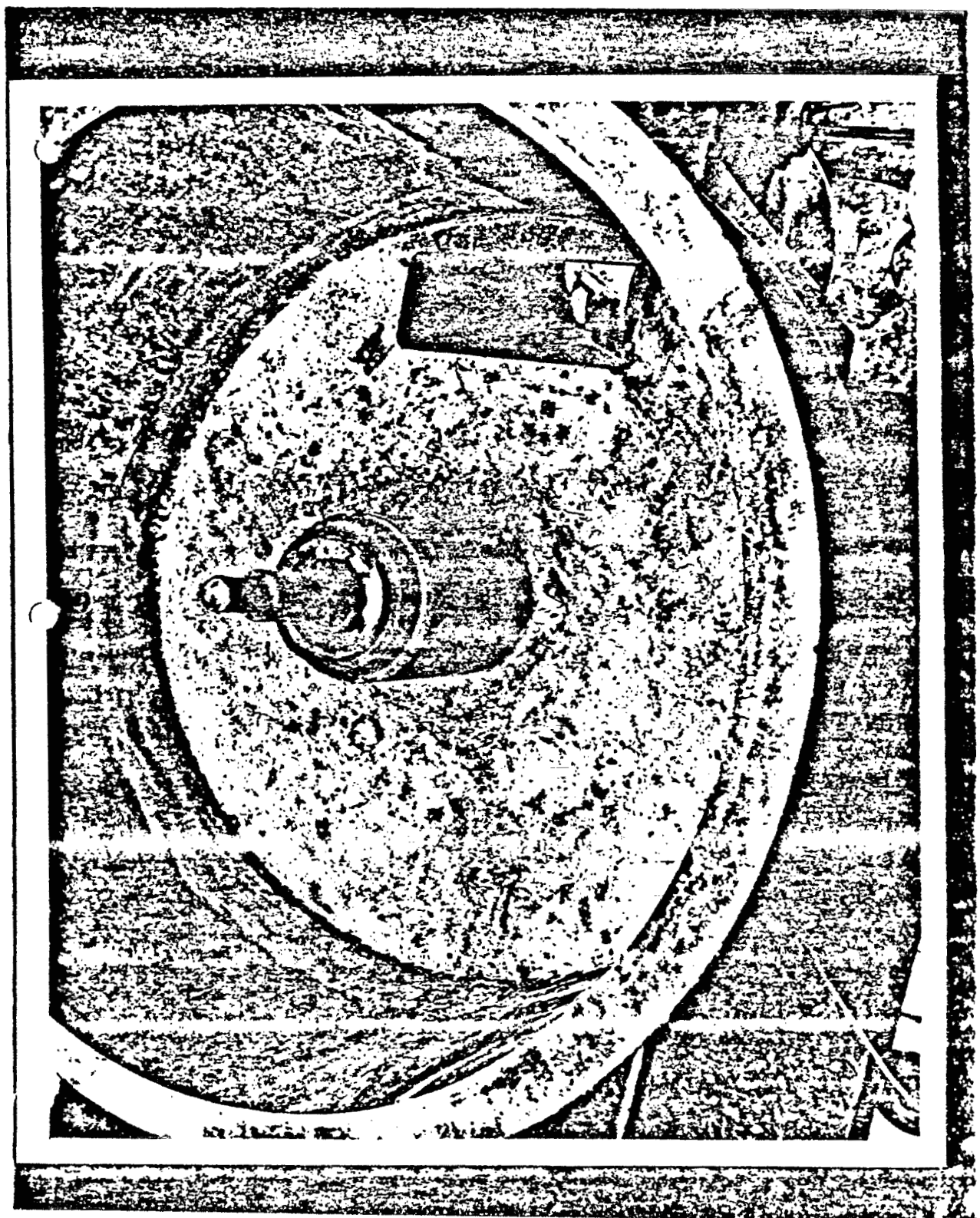




Bay 9 after the explosion.



Mix muller. Dump door/opening is at 9:00 position.

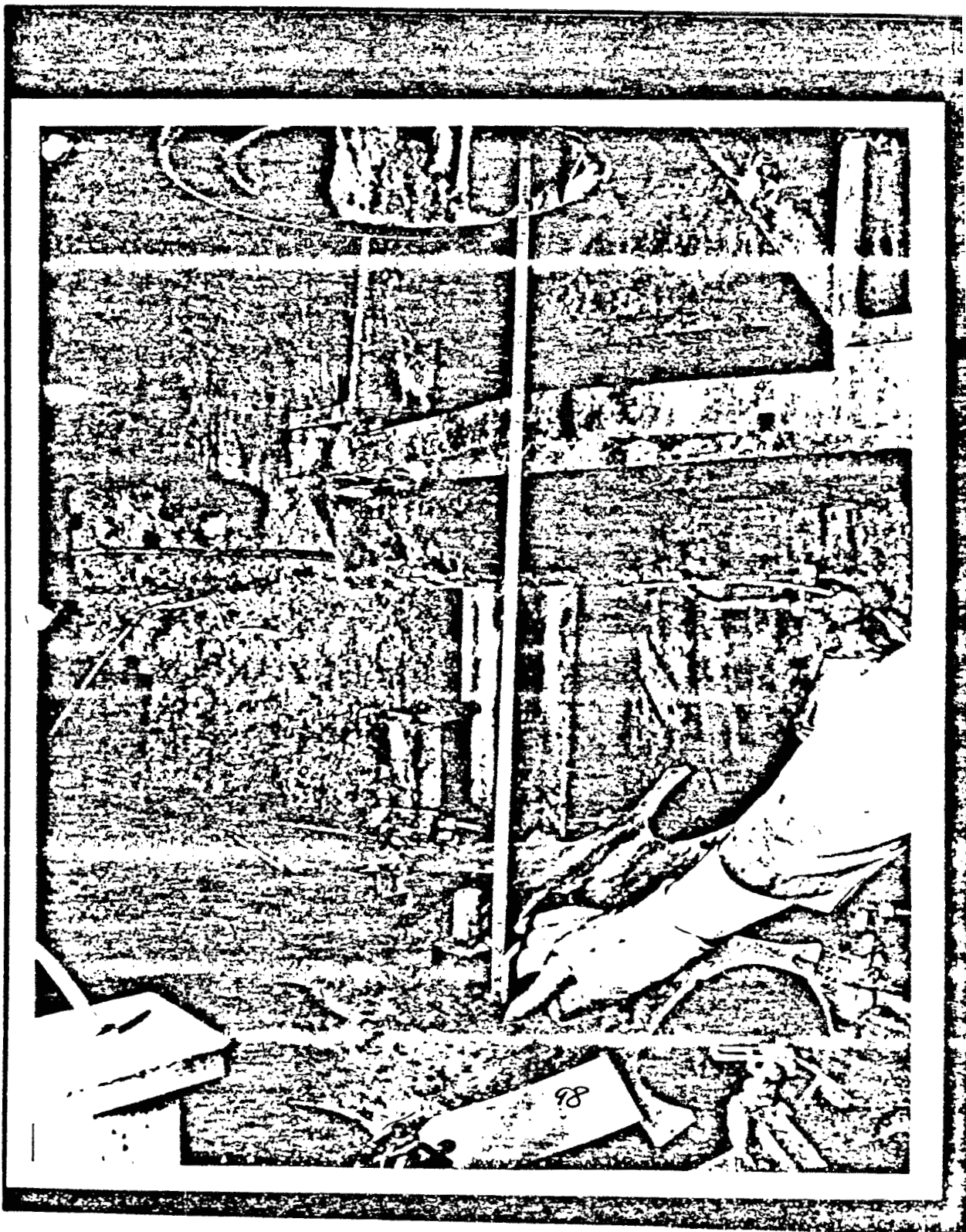


Mix muller with wheel assembly removed.



Collection chute from mixer to dial table.

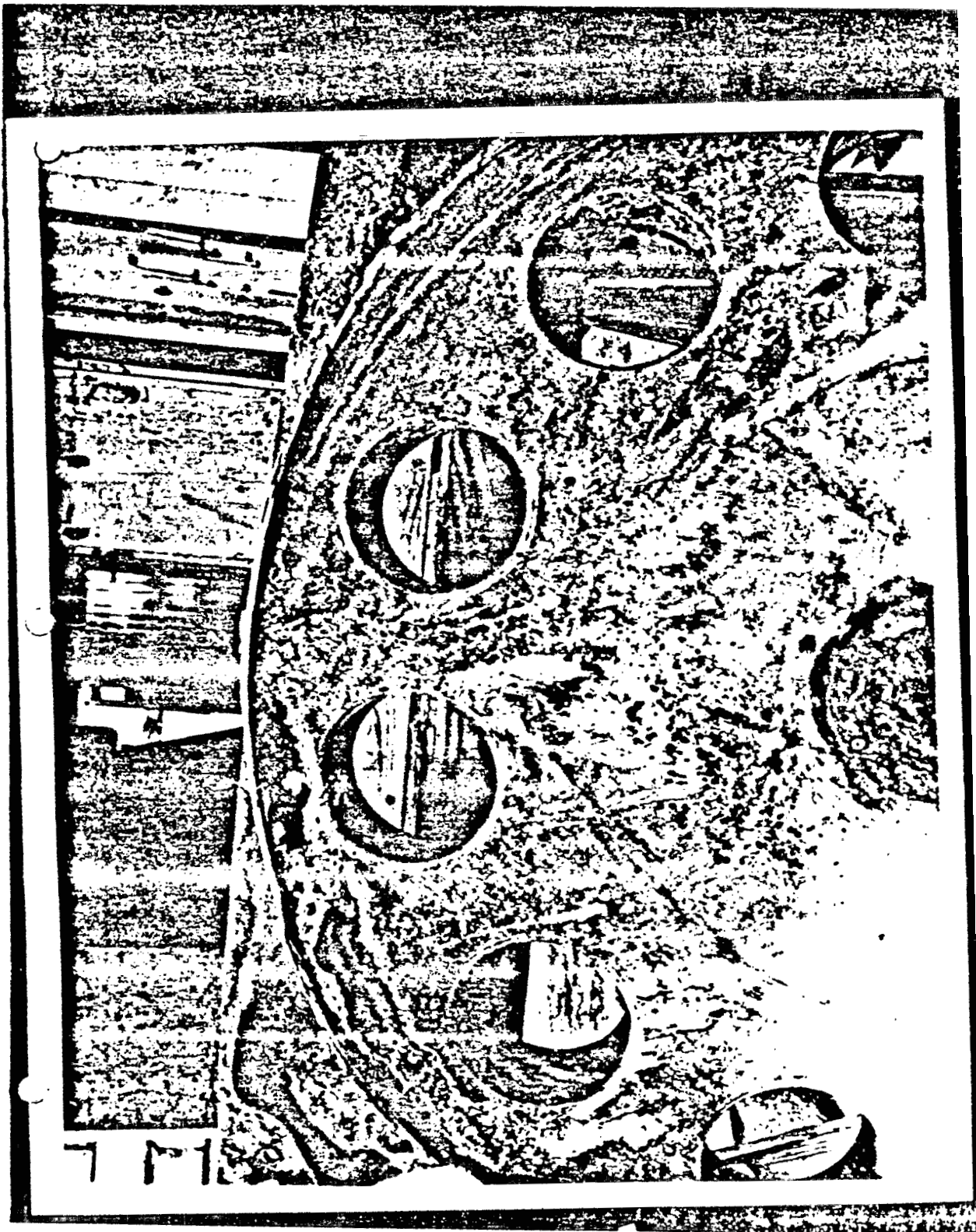




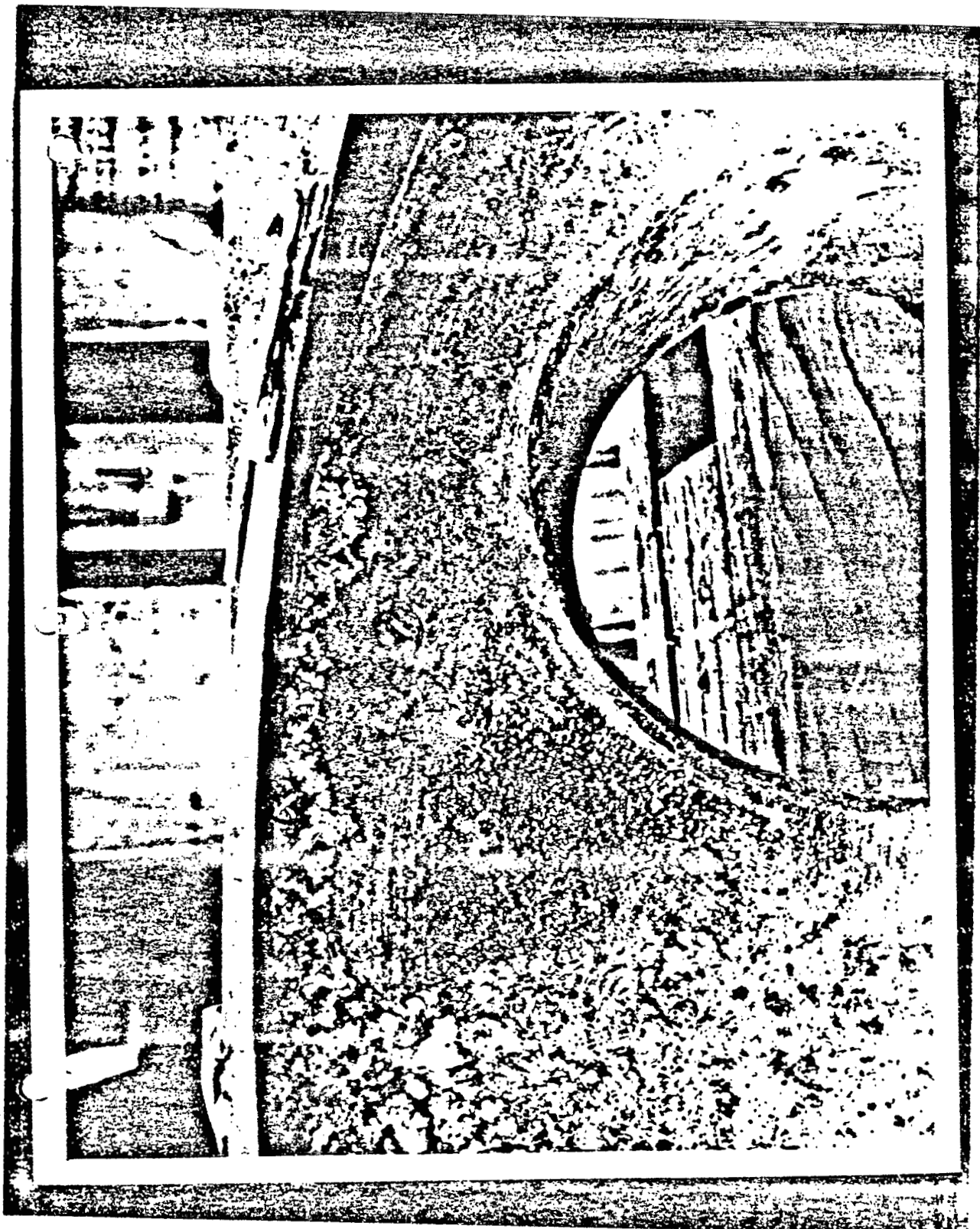
Shows the distance the igniter mix had to drop from the mixer to the dial assembly. (approximately 3.5 ft)



Dial Table



Lower Dial Assembly. Collection containers sit in the holes of the assembly.



Lower dial assembly near possible point of ignition.





Lower assembly after the explosion is in the center of the picture.